

This Page Is Inserted by IFW Operations  
and is not a part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,  
please do not report the images to the  
Image Problems Mailbox.**



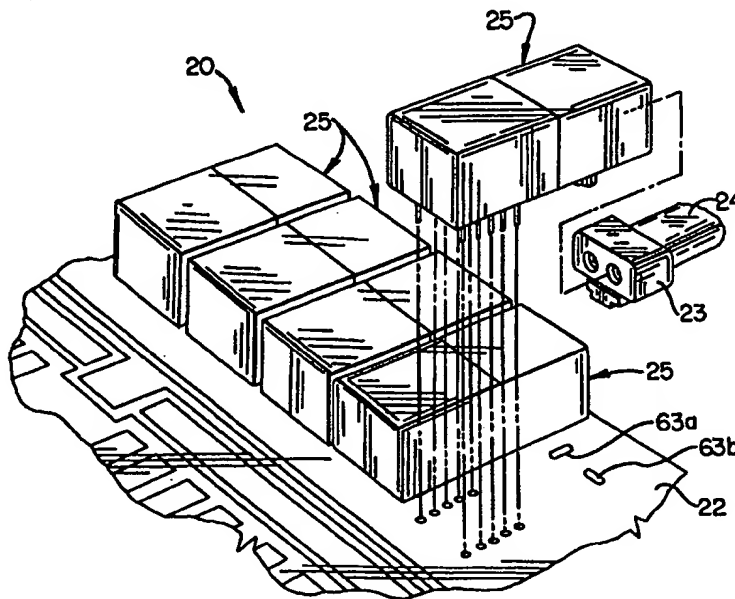
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification<sup>6</sup>:</b> <b>G02B 6/42</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 99/54772</b> <b>(43) International Publication Date:</b> 28 October 1999 (28.10.99)
<b>(21) International Application Number:</b> PCT/US99/08447 <b>(22) International Filing Date:</b> 16 April 1999 (16.04.99) <b>(30) Priority Data:</b> 09/063,190                      20 April 1998 (20.04.98)                      US <b>(71) Applicant (for all designated States except US):</b> METHODE ELECTRONICS OF FLORIDA, INC. [US/US]; Suite A, 3950 Dow Road, Melbourne, FL 32934 (US). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only):</b> SCHARF, Robert, M. [US/US]; 5425 Willoughby Drive, Melbourne, FL 32934 (US). LORD, Randal, B. [US/US]; 4358 Davidia Drive, Melbourne, FL 32934 (US). <b>(74) Agent:</b> REGAN, Christopher, F.; Allen, Dyer, Doppelt, Milbrath & Gilchrist, P.A., Suite 1401, 255 South Orange Avenue, Orlando, FL 32802-3791 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>

**(54) Title:** TRANSCEIVER WITH INTEGRAL SERIAL-TO-PARALLEL CONVERSION AND ASSOCIATED METHOD

**(57) Abstract**

An optical transceiver module includes a transmitter portion and a receiver portion positioned within a housing with an EMI shield therebetween, and wherein the transmitter and receiver portions include respective substrates, or circuit boards, with opposing and spaced apart major surfaces. The port density, when using a plurality of such modules, is increased, while providing enhance EMI shielding. Each circuit board may include a ground plane and have a plurality of generally L-shaped conductive leads extending outwardly from the respective circuit boards. The optical transmitter and optical receiver portions each preferably further comprise at least one active component mounted on the first major surfaces. Accordingly, these active components face one another. The optical transmitter portion preferably further includes an optical emitter connected to an end of the first circuit board, and the optical receiver portion preferably further comprises an optical detector carried by an end of the second circuit board. In addition, the housing preferably includes an integrally formed transverse bulkhead with respective openings receiving the optical emitter and the optical detector. The transverse bulkhead also defines a forward cavity for receiving an optical fiber connector. The housing may have a generally rectangular elongate shape and have a series of longitudinally extending slots therein. The EMI shield, and first and second substrates or circuit boards may be received in these slots for convenience of assembly.



**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

**TRANSCIVER WITH INTEGRAL SERIAL-TO-PARALLEL  
CONVERSION AND ASSOCIATED METHOD**

**Field of the Invention**

The invention is directed to the field of electronic devices and components, and, more particularly, to a transceiver module including an optical transmitter and an optical receiver.

**Background of the Invention**

Optical transmitters and receivers are widely used in communications applications, such as for Local Area Networks (LAN), for example. An optical transmitter typically produces either analog or digital optical signals based upon input electrical signals. Similarly, an optical receiver receives optical signals and produces output electrical signals. The optical signals are often carried by a fiber optic cable which guides the optical signals at a relatively low loss. Moreover, optical signals carried over fiber cables are relatively immune to electrical noise sources as may affect other types of communications via copper wires, for example. Another advantage of optical fiber communication is that information signals having relatively high bandwidths can be carried.

For many applications, such as for a LAN, two-way communications are desirable. Accordingly, an optical transmitter and receiver may be paired within a housing and thereby defining a so-called optical transceiver module. Moreover, since a relatively large

number of such two-way links may need to be established, an optical transceiver module may desirably be relatively small so that a high "port density" can be achieved in an apparatus employing a large number of transceiver modules. In other words, a large number of optical transceivers may be collocated within a common housing and connected to common circuitry, such as at a distribution point for an optical LAN.

10 U.S. Patent No. 5,604,831 to Dittman et al. discloses an optical transceiver module including a pair of side-by-side circuit board portions, for respective transmitter and receiver devices, and enclosed within an overall housing. Connector pins  
15 extend outwardly from the plane of the circuit boards. Along these lines, U.S. Patent No. 5,047,835 to Corradetti et al. discloses an optical transceiver module including a pair of side-by-side connectors, and their horizontally positioned associated circuit boards  
20 within an overall housing. The housing includes a transversely extending wall for mounting the optical devices. U.S. Patent No. 5,109,454 to Okuno et al. discloses another optical transceiver module with side-by-side circuit boards mounted horizontally and  
25 separated by a plastic housing portion.

Unfortunately, as the speed or operating frequencies of the transmitter and receiver are increased, electromagnetic interference (EMI) may be coupled between these circuit portions. The EMI or  
30 noise difficulties may become more severe as the sizes of the circuit boards and components are reduced in an effort to increase port density. U.S. Patent No. 5,047,835 to Chang discloses an overall EMI shield and heat sink which covers the circuit board which, in  
35 turn, mounts both the transmitter and receiver circuitry. U.S. Patent No. 5,117,476 to Yingst et al. discloses an optical transceiver including a common

horizontally extending circuit board with individual shields over the transmitter and receiver circuit portions.

Unfortunately, conventional optical  
5 transceiver modules are relatively large, especially in terms of their widths, and therefore, the port density may be too low for many useful commercial applications. Moreover, EMI may still be a problem for an optical transceiver, especially as sizes are reduced and higher  
10 operating frequencies are used.

#### Summary of the Invention

In view of the foregoing background, it is therefore an object of the present invention to provide an optical transceiver module which is relatively  
15 compact to thereby provide increased port density when combined with other modules.

It is another object of the present invention to provide an optical transceiver module and associated method having enhanced resistance to internally  
20 generated EMI.

These and other objects, features and advantages in accordance with the present invention are provided by an optical transceiver module comprising a transmitter portion and receiver portion positioned  
25 within a housing with an EMI shield therebetween, and wherein the transmitter and receiver portions comprise respective substrates with opposing spaced apart major surfaces. Considered in somewhat different terms, the substrates are turned on their sides into a vertical  
30 orientation with the vertical shield positioned between the substrates within the housing. Accordingly, the port density when using a plurality of such modules is increased, while providing enhanced EMI shielding.

The first and second substrates preferably  
35 comprise respective first and second circuit boards. In addition, each substrate may preferably further include a ground plane. The ground planes may be provided by

respective conductive layers carried on the second major surfaces or outside surfaces of the substrates. The ground planes and the EMI shield serve to sandwich the active components.

5           Each circuit board may carry a plurality of generally L-shaped conductive leads extending outwardly for connection to a mounting circuit board, for example. The optical transmitter and optical receiver portions each preferably further comprise at least one  
10 active component mounted on the first major surfaces. Accordingly, these active components face one another as positioned in the housing.

          According to another advantageous aspect of the present invention, the optical transmitter portion  
15 preferably further comprises an optical emitter carried by an end of the first circuit board. The optical receiver portion preferably further comprises an optical detector carried by an end of the second circuit board. In addition, the housing preferably  
20 includes an integrally formed transverse bulkhead with respective openings receiving the optical emitter and the optical detector. The transverse bulkhead also defines a forward cavity for receiving an optical fiber connector.

25           The housing may have a generally rectangular elongate shape and have a series of longitudinally extending slots therein. The EMI shield, and the first and second substrates or circuit boards may be received in respective pairs of slots for convenience of  
30 assembly. The EMI shield and the housing preferably comprise an electrically conductive material. The housing may comprise a forward portion and a rearward portion also to facilitate assembly. The housing also preferably further comprises a plurality of keyed  
35 mounting projections extending outwardly from a predetermined surface to facilitate mounting. Of course, a plurality of such transceiver modules may be

assembled in side-by-side relation on the mounting circuit board to thereby provide a high port density for the apparatus.

A method aspect of the invention is for  
5 making an optical transceiver module of a type comprising a housing, an optical transmitter portion comprising a first substrate having a first major surface, and an optical receiver portion comprising a second substrate having a first major surface. The  
10 method preferably comprises the steps of positioning the first and second substrates within the housing so that the respective first and second major surfaces are opposing and in spaced apart relation from one another, and positioning an EMI shield within the housing and  
15 extending between the first and second major surfaces of the first and second substrates.

Another method aspect of the invention is also for making an optical transceiver module and preferably comprises the steps of forming a housing to  
20 have a generally rectangular elongate outer portion, and an integrally formed transverse bulkhead having first and second openings therein and defining a forward cavity for receiving an optical fiber connector therein; and, positioning an optical transmitter  
25 portion within the housing comprising a first substrate and an optical emitter carried by an end of the first substrate in registration with the first opening in the bulkhead. The method also preferably further includes the step of positioning an optical receiver portion  
30 within the housing comprising a second substrate and an optical detector carried by an end of the second substrate aligned in registration with the second opening of the bulkhead. An EMI shield is preferably positioned within the housing and extends between the  
35 first and second substrates.

#### Brief Description of the Drawings



FIG. 1 is a perspective view of a portion of an apparatus including a plurality of optical transceiver modules in accordance with the present invention.

5           FIG. 2 is a front perspective view of an optical transceiver module and associated optical fiber cable and connector as shown in FIG. 1.

          FIG. 3 is a top plan view of an optical transceiver module as shown in FIG. 1 with the rearward  
10 housing portion removed and with the ground planes on the substrates shown with an exaggerated thickness for clarity.

          FIG. 4 is a bottom plan view of an optical transceiver module as shown in FIG. 1 with the rearward  
15 housing portion removed and with the ground planes on the substrates shown with an exaggerated thickness for clarity.

          FIG. 5 is a side elevational view of an optical transceiver module as shown in FIG. 1 with the  
20 rearward housing portion removed.

          FIG. 6 is a rear elevational view of an optical transceiver module as shown in FIG. 1 with the rearward housing portion removed.

          FIG. 7 is a front elevational view of an optical transceiver module as shown in FIG. 1 with the  
25 rearward housing portion removed.

          FIG. 8 is a cross-sectional view taken along line 8-8 of FIG. 7.

          FIG. 9 is a top plan view of the forward  
30 housing portion of the optical transceiver module as shown in FIG. 1 illustrated without the rearward housing portion, and without the transmitter and receiver circuit boards.

          FIG. 10 is a rear elevational view of the  
35 forward housing portion of the optical transceiver module as shown in FIG. 1 illustrated without the

-7-

rearward housing portion, and without the transmitter and receiver circuit boards.

FIG. 11 is a bottom plan view of the forward housing portion of the optical transceiver module as shown in FIG. 1 illustrated without the rearward housing portion, and without the transmitter and receiver circuit boards.

#### Detailed Description of the Preferred Embodiments

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring first to FIG. 1, an electronic communication apparatus 20 including a plurality of optical transceiver modules 25 in accordance with the present invention is explained. The modules 25 are illustratively mounted on a mother board or mounting circuit board 22 as will be readily appreciated by those skilled in the art. As will also be appreciated by those skilled in the art, an overall housing, not shown, may protect the mounting circuit board 22 for the apparatus 20b. The transceiver module 25 in accordance with the present invention may be made relatively small in size to thereby achieve a high port density when combined with the other optical transceiver modules in the apparatus 20. Such an apparatus 20 may be used for an optical fiber LAN, for example. Of course, a plurality of optical

transceivers 25 may also be used in other applications. Moreover, an optical transceiver module 25 may be used by itself, such as for an optical-to-electrical signal interfacing at a computer, for example.

5           A mating optical fiber connector 23, including an attached fiber optic cable 24, may be connected to each transceiver module 25 as will also be readily appreciated by those skilled in the art. The optical fiber cable 24 may include two fibers, not  
10 shown, -- a first fiber for the transmit direction, and a second fiber for the receive direction.

Turning now additionally to FIGS. 2-11, the optical transceiver module 25 in accordance with the present invention is further described. The optical  
15 transceiver module 25 illustratively includes a transmitter portion 26 and receiver portion 27 positioned within a generally rectangular elongate housing 30 with an EMI shield 35 between the two portions. The housing 30 illustratively includes a  
20 forward portion 30a and a rearward portion 30b. The transmitter and receiver portions 26, 27 illustratively include respective substrates or circuit boards 36, 37 mounted to have their first major surfaces in opposing spaced apart relation. The circuit boards 36, 37 are  
25 turned on their sides within the housing 30 in a vertical orientation. Thus, the width of the modules 25 may be made relatively small, for example, only about 0.6 inches, so that the port density can be relatively high. The EMI shielding is also enhanced in  
30 the illustrated mounting arrangement.

The transmitter circuit portion 26 illustratively includes a plurality of generally L-shaped conductive pins or leads 40 extending outwardly

from the transmitter circuit board 36. Similarly, the optical receiver portion 27 has a plurality of generally L-shaped conductive leads 41 extending outwardly from the receiver circuit board 37 as shown in the illustrated embodiment. The arrangement of the conductive leads 40, 41 also facilitates the compact shape and ready interconnection for the optical transceiver module 25.

As also shown in the illustrated embodiment, the optical transmitter and optical receiver portions 26, 27 each preferably further comprise at least one respective active component 42, 43 mounted on the first major surfaces which face one another. In the illustrated embodiment, the active components 42, 43 are integrated circuits, although those skilled in the art will appreciate that other active components, such as discrete transistors, resistors, etc. are also contemplated by the present invention. As the circuit boards 36, 37 are positioned, these active components 40, 41 face one another so that signals radiated from the surface of the boards are between conductive portions of the boards and the EMI shield 35.

As shown perhaps best in FIGS. 3 and 4, each circuit board or substrate 36, 37 also preferably carries a conductive ground plane 36a, 37a. In the illustrated embodiment, the ground planes 36a, 37a are carried by the second major surfaces of the boards and are shown in an exaggerated thickness for clarity of explanation. The ground planes 36a, 37a may be provided by a relatively thin conductive layers on the respective circuit boards 36, 37 as will be readily appreciated by those skilled in the art. The ground planes 36a, 37a together with the EMI shield 35 sandwich the active components and greatly reduce or

-10-

prevent EMI difficulties, especially at higher port densities and higher operating frequencies and power. In other words, the sandwich arrangement both protects the active components from radiated noise, as well as  
5 prevents radiation of noise from the active components beyond the shield and ground planes.

The optical transmitter portion 26 also preferably further includes an optical emitter 44 (FIG. 6) connected to or carried by an end of the first  
10 circuit board 36. The optical emitter 44 may be an LED or laser as will be readily appreciated by those skilled in the art. Along these same lines, the optical receiver portion 27 may further include an optical detector 45 (FIG. 6) carried by an end of the  
15 second circuit board 27.

As shown perhaps best in FIGS. 7, 8 and 10, the forward portion 30a of the housing 30 includes an integrally formed transverse bulkhead 50 for receiving the optical emitter 44 and the optical detector 45. The  
20 transverse bulkhead 50 also defines a forward cavity 51 for receiving an optical fiber connector 23 (FIGS. 1 and 2). More particularly, the bulkhead 50 illustratively has two side-by-side openings therein 52, 53 for permitting light communication between  
25 respective fibers and the optical emitter 44 and optical detector 45. The bulkhead 50 and surrounding housing portions also define respective tubular guide channels 54, 55 aligned with the openings and extending into the forward cavity 51. Respective enlarged guide  
30 channels 56, 57 are also defined to the rear of the bulkhead 50 for receiving the optical emitter 44 and optical detector 45.

The forward housing portion 30a may preferably be formed by a metal die casting process as will be readily appreciated by those skilled in the art. The forward portion 30a may also include the  
5 opening 61 on the lower portion to receive a mating portion of the optical connector 23 (FIGS. 1 and 2). The die-cast housing forward portion 30a may have a width on the order of only about 0.6", for example.

In addition, as shown in the illustrated  
10 embodiment, the forward housing portion 30a may include a pair of keyed projections 62a, 62b extending outwardly from the lower portion thereof. The projections 62a, 62b are received within mating openings 63a, 63b (FIG. 1) to facilitate mounting  
15 before the conductive leads 40, 41 are soldered to the mounting board 22 as will also be readily appreciated by those skilled in the art.

As perhaps best shown in FIG. 3, the forward housing portion 30a includes three pairs of upper and  
20 lower longitudinally extending slots 65a, 65b, 66a, 66b, 67a, 67b. A first pair of slots 65a, 65b receives the side edges of the first circuit board 36 of the transmitter portion 26. The second pair of slots 66a, 66b receives the EMI shield 35, and the third pair of  
25 slots 67a, 67b receives the circuit board of 37 of the receiver circuit portion 27. The slotted arrangement facilitates assembly and accurate positioning of the circuit boards 26, 27 and the EMI shield 35 in parallel vertical orientations. The transmitter and receiver  
30 circuit boards 26, 27 are relatively closely positioned, and operate at relatively high operating frequencies, e.g. of 150 MHZ or greater; however, the

EMI shield 35 reduces the potential for coupling noise between the circuit boards.

The EMI shield 35 is preferably an electrically conductive material, such as a metal, and the housing 30 may also be conductive to shield adjacent modules 25. The housing 30 and EMI shield 35 may be tied to a circuit ground on the mounting board 22 by a designated conductive pin as will be readily appreciated by those skilled in the art.

One method aspect of the invention is for making an optical transceiver module 25 of a type comprising a housing 30, an optical transmitter portion 26 comprising a first substrate or circuit board 36 having a first major surface, and an optical receiver portion 27 comprising a second substrate or circuit board 37 having a first major surface. The method preferably comprises the steps of positioning the first and second substrates 36, 37 within the housing 30 so that the respective first and second major surfaces are opposing and in spaced apart relation from one another, and positioning an EMI shield 35 within the housing and extending between the first and second major surfaces of the first and second substrates.

Another method aspect of the invention is also for making an optical transceiver module 35 and preferably comprises the steps of forming a housing 30 to have a generally rectangular elongate outer portion and an integrally formed transverse bulkhead 50 having first and second openings 52, 53 therein and defining a forward cavity 51 for receiving an optical fiber connector 23 therein, and positioning an optical transmitter portion 26 within the housing 30 and comprising a first substrate 36 and an optical emitter

44 carried by an end of the first substrate in registration with the first opening 52 in the bulkhead. The method also preferably further includes the steps of positioning an optical receiver portion 27 within  
5 the housing 30 and comprising a second substrate 37 and an optical detector 45 carried by an end of the second substrate aligned in registration with the second opening 53 of the bulkhead, and positioning an EMI shield 35 within the housing and extending between the  
10 first and second substrates.

Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated  
15 drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.



## THAT WHICH IS CLAIMED IS:

1. An optical transceiver module comprising:
  - 5 a housing;  
an optical transmitter portion positioned within said housing and comprising a first substrate having a first major surface;  
an optical receiver portion positioned within  
10 said housing and comprising a second substrate having a first major surface in opposing and spaced apart relation from the first major surface of said first substrate; and  
an electromagnetic interference (EMI) shield  
15 positioned within said housing and extending between the first and second major surfaces of said first and second substrates.
2. An optical transceiver module according to Claim 1 further comprising respective first and  
20 second ground planes on the first and second substrates.
3. An optical transceiver module according to Claim 1 wherein said first and second substrates  
25 comprise respective first and second circuit boards.
4. An optical transceiver module according to Claim 3 wherein said optical transmitter portion further comprises a first plurality of L-shaped  
30 conductive leads extending outwardly from said first circuit board; and wherein said optical receiver portion further comprises a second plurality of generally L-shaped conductive leads extending outwardly from said second circuit board.  
35
5. An optical transceiver module according to Claim 3 wherein said optical transmitter portion

further comprises at least one active component mounted on the first major surface of said first circuit board; and wherein said optical receiver portion further comprises at least one active component mounted on the  
5 first major surface of said second circuit board.

6. An optical transceiver module according to Claim 3 wherein said optical transmitter portion further comprises an optical emitter carried by an end  
10 of said first circuit board; and wherein said optical receiver portion further comprises an optical detector carried by an end of said second circuit board.

7. An optical transceiver module according to Claim 6 wherein said housing comprises an integrally  
15 formed transverse bulkhead having respective openings therein receiving said optical emitter and said optical detector and defining a forward cavity for receiving an optical fiber connector therein.

20

8. An optical transceiver module according to Claim 1 wherein said housing comprises a series of longitudinally extending slots on interior surface portions thereof; and wherein said first substrate,  
25 said second substrate and said EMI shield are received in respective pairs of said slots.

9. An optical transceiver module according to Claim 1 wherein said EMI shield comprises an electrically conductive material.

30

10. An optical transceiver module according to Claim 1 wherein said housing has a generally rectangular elongate shape.

11. An optical transceiver module according to Claim 10 wherein said housing comprises a forward  
35 portion and a rearward portion.

12. An optical transceiver module according to Claim 1 wherein said housing comprises an electrically conductive material.

13. An optical transceiver module according to Claim 1 wherein said housing further comprises a plurality of keyed mounting projections extending outwardly from a predetermined surface thereof.

14. An optical transceiver module comprising:  
a housing having a generally rectangular elongate shape and a series of longitudinally extending slots on interior surface portions thereof;  
an optical transmitter portion positioned within respective slots in said housing and comprising a first generally elongate circuit board having a first major surface;  
an optical receiver portion positioned within respective slots in said housing and comprising a second generally elongate circuit board having a first major surface in opposing and spaced apart relation from the first major surface of said first circuit board; and  
an electromagnetic interference (EMI) shield positioned within respective slots in said housing and extending between the first and second major surfaces of said first and second circuit boards.

15. An optical transceiver module according to Claim 14 further comprising respective first and second ground planes on said first and second circuit boards.

16. An optical transceiver module according to Claim 15 wherein said first and second ground planes are on respective second major faces of said first and second circuit boards.

17. An optical transceiver module according to Claim 14 wherein said optical transmitter portion further comprises a first plurality of generally L-shaped conductive leads extending outwardly from said first circuit board; and wherein said optical receiver portion further comprises a second plurality of generally L-shaped conductive leads extending outwardly from said second circuit board.

18. An optical transceiver module according to Claim 14 wherein said optical transmitter portion further comprises at least one active component mounted on the first major surface of said first circuit board; and wherein said optical receiver portion further comprises at least one active component mounted on the first major surface of said second circuit board.

19. An optical transceiver module according to Claim 14 wherein said optical transmitter portion further comprises an optical emitter connected to an end of said first circuit board; and wherein said optical receiver portion further comprises an optical detector at an end of said second circuit board.

20. An optical transceiver module according to Claim 19 wherein said housing comprises an integrally formed transverse bulkhead and respective openings therein receiving said optical emitter and said optical detector and defining a forward cavity for receiving an optical fiber connector therein.

21. An optical transceiver module according to Claim 14 wherein said EMI shield comprises an electrically conductive material.

22. An optical transceiver module comprising:

a housing comprising a generally rectangular elongate outer portion and an integrally formed transverse bulkhead having first and second openings therein and defining a forward cavity for receiving an  
5 optical fiber connector therein;

an optical transmitter portion positioned within said housing and comprising a first substrate and an optical emitter carried by an end of said first substrate to be positioned in registration with the  
10 first opening in said bulkhead;

an optical receiver portion positioned within said housing and comprising a second substrate and an optical detector carried by an end of said second substrate to be positioned in registration with the  
15 second opening of said bulkhead; and

an electromagnetic interference (EMI) shield positioned within said housing and extending between the first and second substrates.

20 23. An optical transceiver module according to Claim 22 wherein said first substrate has a first major surface, and said second substrate has a second major surface; and wherein said first and second substrates are positioned so that the first and second  
25 major surfaces are in opposing spaced apart relation with said EMI shield positioned therebetween.

24. An optical transceiver module according to Claim 23 wherein said first and second substrates comprise respective first and second circuit boards.  
30

25. An optical transceiver module according to Claim 24 further comprising respective first and second ground planes on said first and second circuit boards.

35 26. An optical transceiver according to Claim 25 wherein said first and second ground planes

are on respective second major surfaces of said first and second circuit boards.

27. An optical transceiver module according  
5 to Claim 24 wherein said optical transmitter portion further comprises a first plurality of generally L-shaped conductive leads extending outwardly from said first circuit board; and wherein said optical receiver  
10 portion further comprises a second plurality of generally L-shaped conductive leads extending outwardly from said second circuit board.

28. An optical transceiver module according  
to Claim 24 wherein said optical transmitter portion  
15 further comprises at least one active component mounted on the first major surface of said first circuit board; and wherein said optical receiver portion further  
comprises at least one active component mounted on the  
first major surface of said second circuit board.

20

29. An optical transceiver module according  
to Claim 22 wherein said housing comprises a series of  
longitudinally extending slots on interior surface  
portions thereof; and wherein said first substrate,  
25 said second substrate and said EMI shield are received in respective pairs of slots.

30. An apparatus for optical communication  
comprising:  
30 a mounting circuit board; and  
a plurality of optical transceiver modules  
mounted on said mounting circuit board, each of said  
optical transceiver modules comprising  
a housing,  
35 an optical transmitter portion  
positioned within said housing and comprising

a first substrate having a first major surface,

an optical receiver portion positioned within said housing and comprising a second substrate having a first major surface in opposing and spaced apart relation from the first major surface of said first substrate, and

an electromagnetic interference (EMI) shield positioned within said housing and extending between the first and second major surfaces of said first and second substrates.

31. An apparatus according to Claim 30 further comprising respective first and second ground planes on said first and second substrates.

32. An apparatus according to Claim 30 wherein said first and second substrates comprise respective first and second circuit boards.

33. An apparatus according to Claim 32 wherein said optical transmitter portion further comprises a first plurality of generally L-shaped conductive leads extending outwardly from said first circuit board; wherein said optical receiver portion further comprises a second plurality of generally L-shaped conductive leads extending outwardly from said second circuit board; and wherein said first and second pluralities of conductive leads are connected to said mounting circuit board.

34. An apparatus according to Claim 32 wherein said optical transmitter portion further comprises at least one active component mounted on the first major surface of said first circuit board; and wherein said optical receiver portion further comprises at least one active component mounted on the first major surface of said second circuit board.

35. An apparatus according to Claim 32 wherein said optical transmitter portion further comprises an optical emitter carried by an end of said first circuit board; and wherein said optical receiver  
5 portion further comprises an optical detector carried by an end of said second circuit board.

36. An apparatus according to Claim 35 wherein said housing comprises an integrally formed  
10 transverse bulkhead having respective openings receiving said optical emitter and said optical detector and defining a forward cavity for receiving an optical fiber connector therein.

37. An apparatus according to Claim 30 wherein said housing further comprises a plurality of keyed mounting projections extending outwardly from a predetermined surface thereof and being received in corresponding openings in said mounting circuit board.  
20

38. A method for making an optical transceiver module of a type comprising a housing, an optical transmitter portion comprising a first substrate having a first major surface, and an optical  
25 receiver portion comprising a second substrate having a first major surface, the method comprising the steps of:

positioning the first and second substrates within the housing so that the respective first and  
30 second major surfaces are opposing and spaced apart relation from one another; and

positioning an electromagnetic interference (EMI) shield within the housing and extending between the first and second major surfaces of the first and  
35 second substrates.

39. A method according to Claim 38 further comprising the step of providing respective first and



-22-

second ground planes on the first and second substrates.

40. A method according to Claim 38 wherein  
5 said optical transmitter portion further comprises at least one active component mounted on the first major surface; and wherein said optical receiver portion further comprises at least one active component mounted on the first major surface.

10

41. A method according to Claim 38 wherein  
said housing comprises an integrally formed transverse bulkhead; wherein said optical transmitter portion further comprises an optical emitter carried by an end  
15 of the first substrate; wherein said optical receiver portion further comprises an optical detector carried by an end of said second circuit board; and wherein the step of positioning the first and second substrates comprises positioning same so that the optical emitter  
20 and optical detector are positioned in respective openings in said bulkhead.

42. A method according to Claim 38 wherein  
said housing comprises a series of longitudinally  
25 extending slots therein; and wherein the steps of positioning the first and second substrates and the EMI shield comprises positioning same in respective pairs of longitudinally extending slots.

30 43. A method for making an optical transceiver module comprising the steps of:

forming a housing to have a generally rectangular elongate outer portion and an integrally formed transverse bulkhead having first and second  
35 openings therein and defining a forward cavity for receiving an optical fiber connector therein;

positioning an optical transmitter portion within said housing and comprising a first substrate and an optical emitter carried by an end of said first substrate in registration with the first opening in  
5 said bulkhead;

positioning an optical receiver portion within said housing and comprising a second substrate and an optical detector carried by an end of said second substrate aligned in registration with the  
10 second opening of said bulkhead; and

positioning an electromagnetic interference (EMI) shield within said housing and extending between the first and second substrates.

44. A method according to Claim 43 further  
15 comprising the step of providing respective first and second ground planes on the first and second substrates.

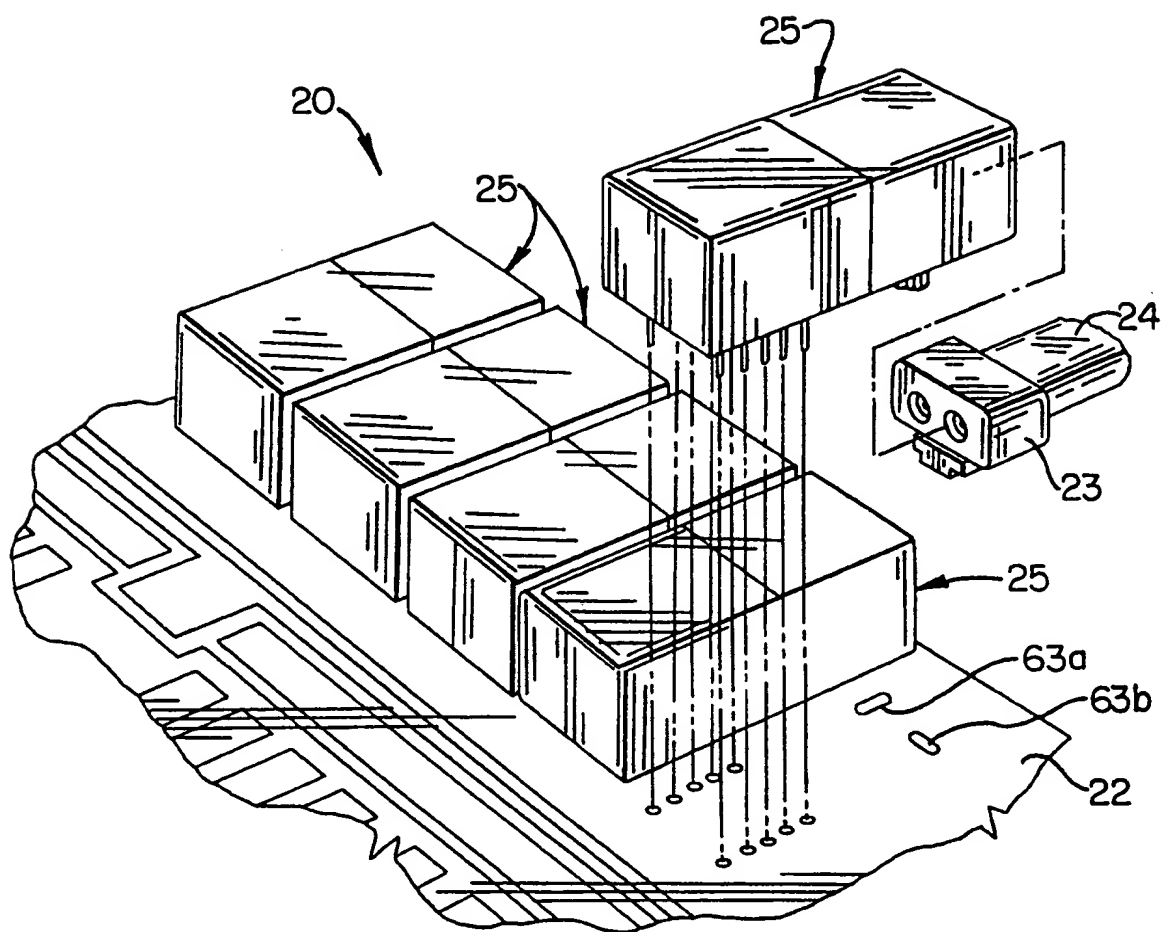
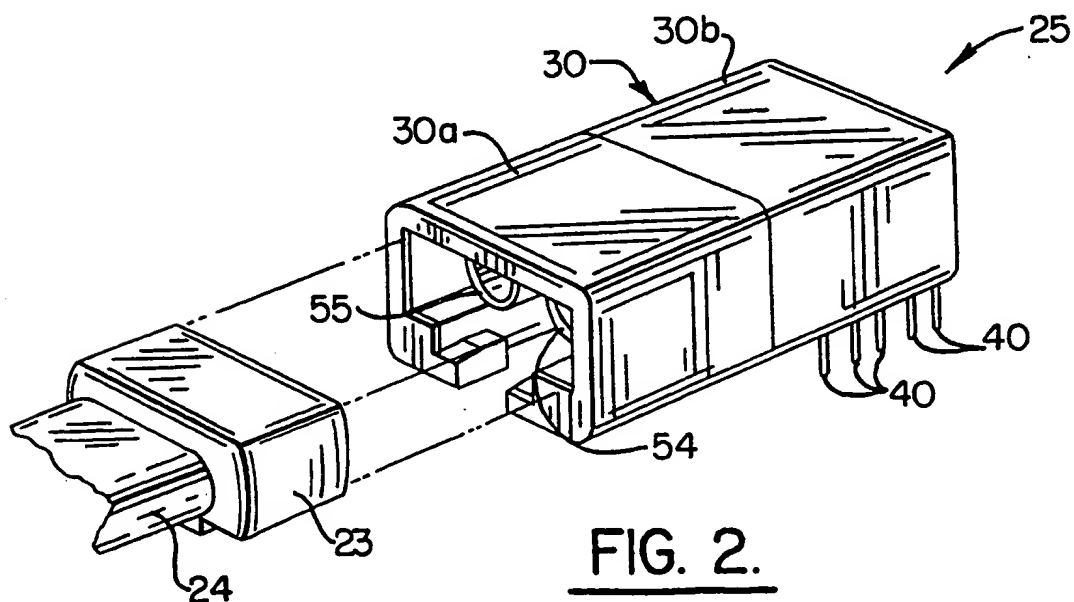
45. An method according to Claim 43 wherein  
20 said first substrate has a first major surface, and said second substrate has a second major surface; and wherein the step of positioning comprises positioning the first and second substrates so that the first and second major surfaces are in opposing and spaced apart  
25 relation with said EMI shield positioned therebetween.

46. A method according to Claim 43 wherein said optical transmitter portion further comprises at least one active component mounted on the first major;  
30 and wherein said optical receiver portion further comprises at least one active component mounted on the first major surface.

47. A method according to Claim 43 wherein  
35 said housing comprises a series of longitudinally extending slots therein; and wherein the steps of positioning the first and second substrates and the EMI

shield comprises positioning same in respective pairs of longitudinally extending slots.

1/5

FIG. 1.FIG. 2.

2/5

25

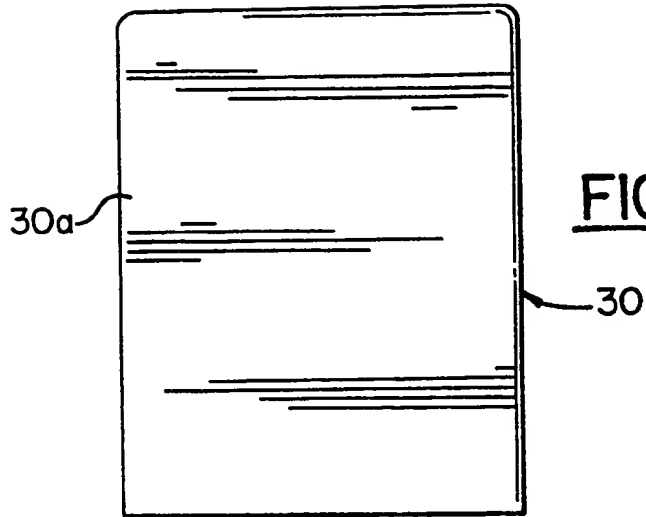


FIG. 3.

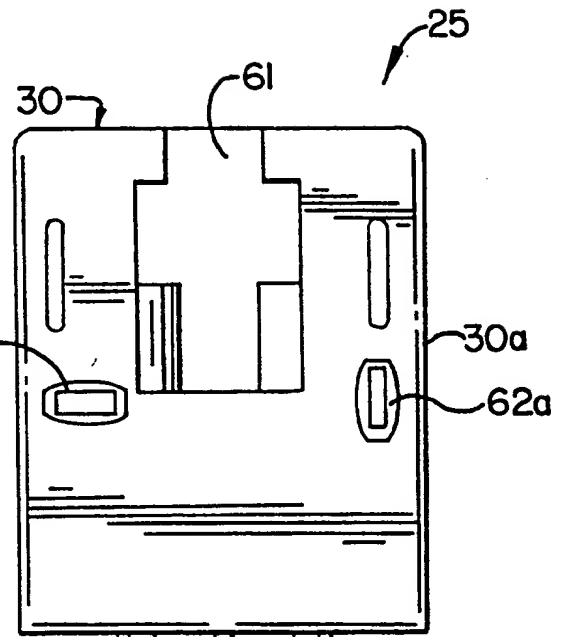
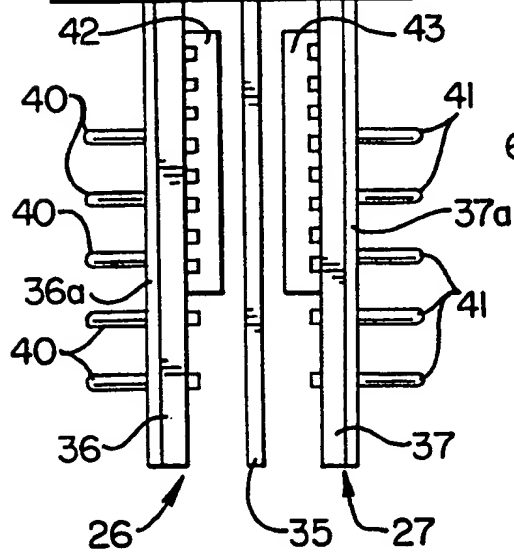
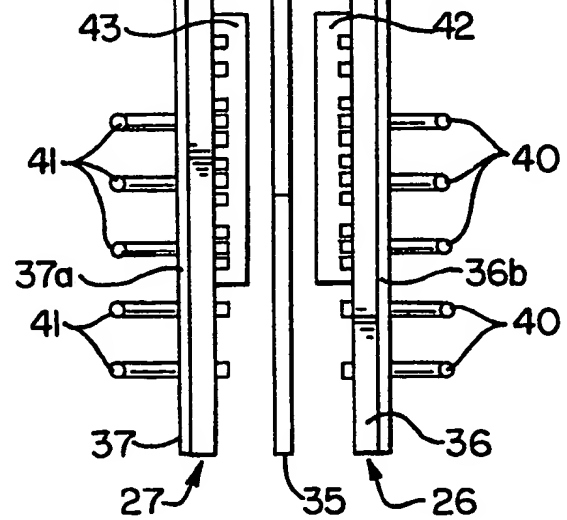
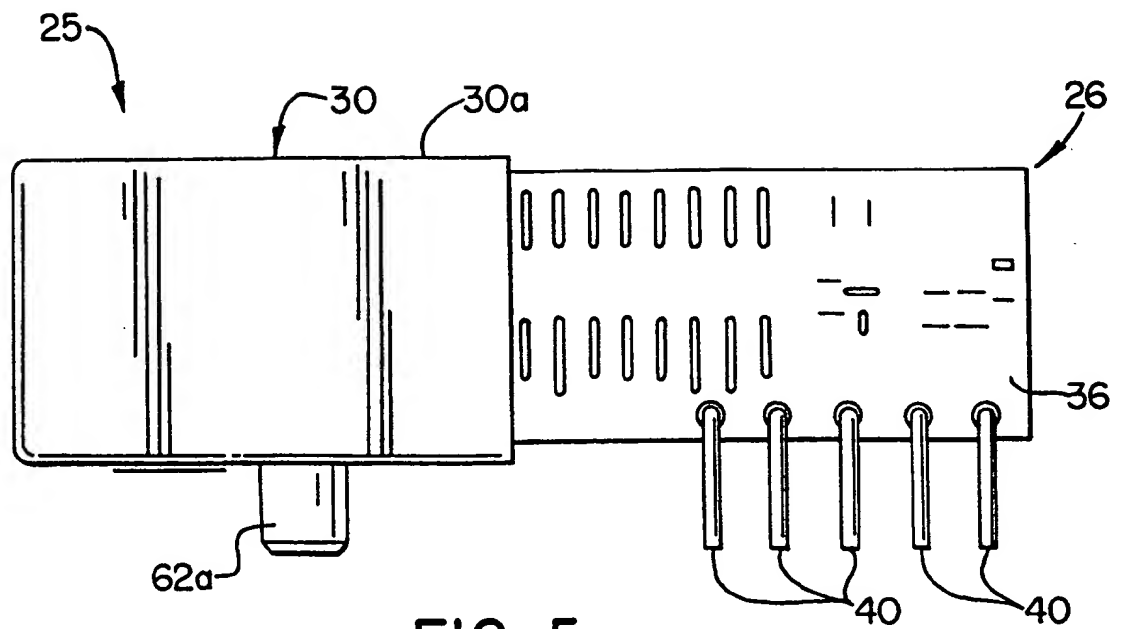
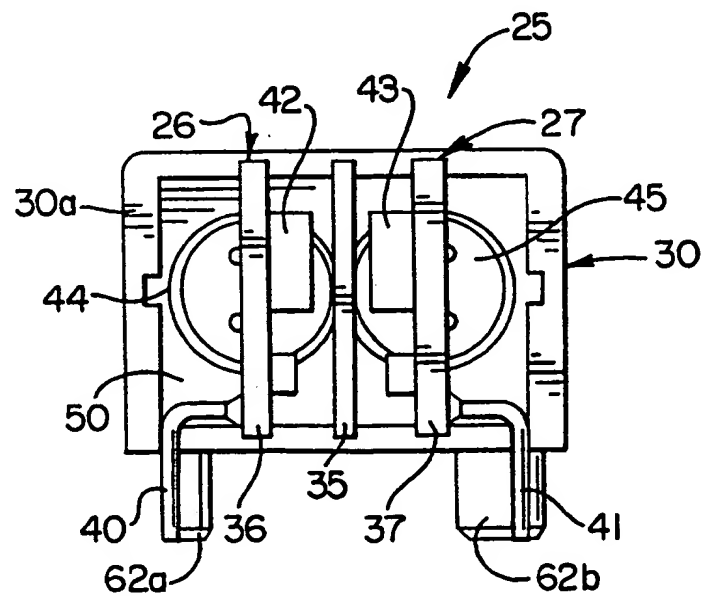


FIG. 4.



3/5

FIG. 5.FIG. 6.

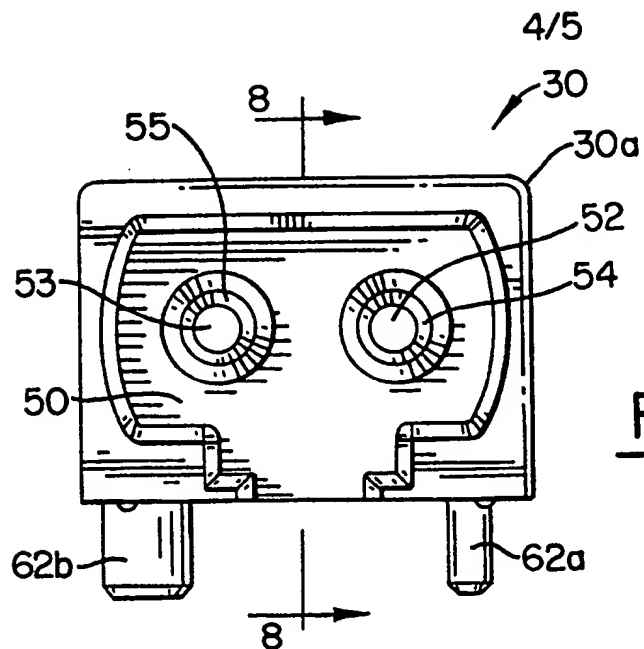


FIG. 7.

FIG. 8.

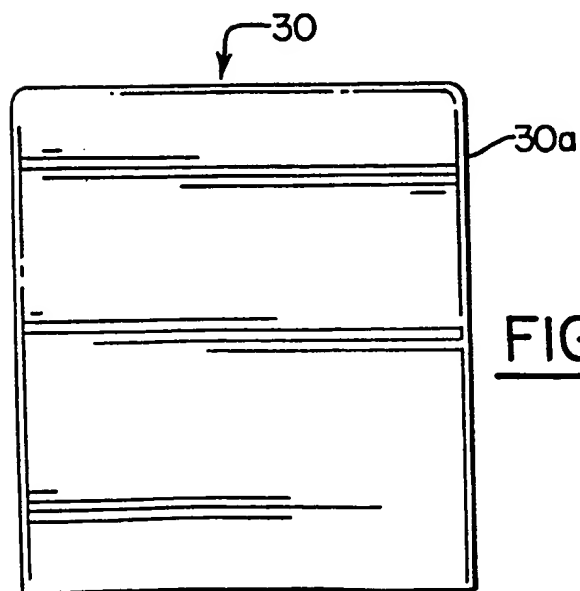
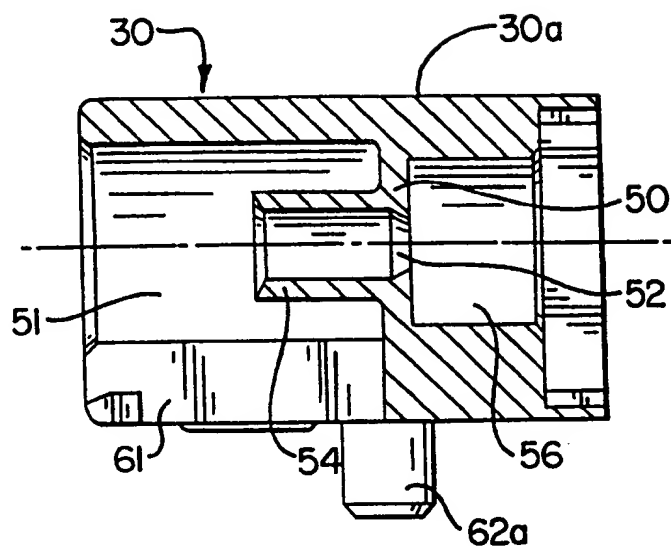


FIG. 9.

5/5

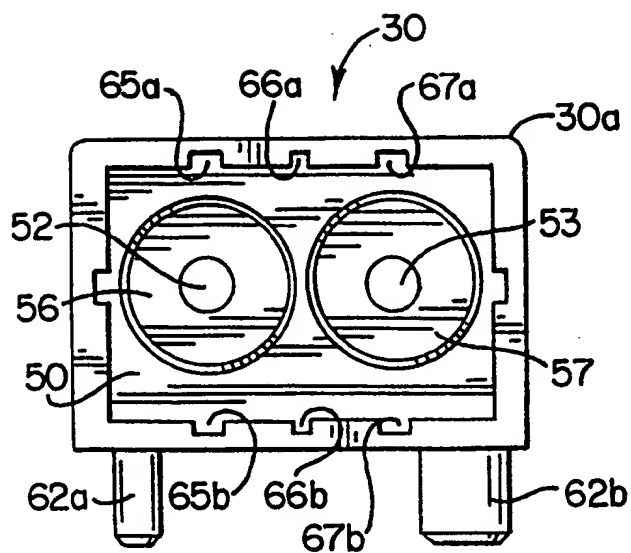
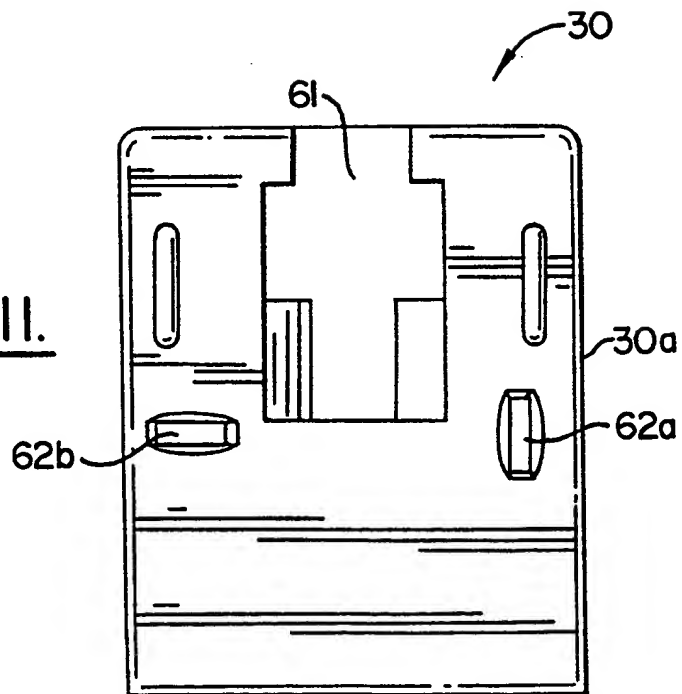


FIG. 10.

FIG. 11.





# INTERNATIONAL SEARCH REPORT

Inter. onal Application No

PCT/US 99/08447

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 G02B6/42

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 097, no. 010, 31 October 1997 (1997-10-31) & JP 09 171127 A (MATSUSHITA ELECTRIC IND CO LTD), 30 June 1997 (1997-06-30) abstract	1-3,5-7, 9,12, 30-32, 34,35
A		14,22, 38,43
X	PATENT ABSTRACTS OF JAPAN vol. 013, no. 338 (E-795), 28 July 1989 (1989-07-28) & JP 01 098299 A (FUJITSU LTD), 17 April 1989 (1989-04-17) abstract	1-3,5-7, 9,12, 30-32, 34,35
A		14,22, 38,43
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

6 August 1999

Date of mailing of the international search report

13/08/1999

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Jakober, F

## INTERNATIONAL SEARCH REPORT

Inter. Appl. Application No

PCT/US 99/08447

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 096, no. 011, 29 November 1996 (1996-11-29) & JP 08 194129 A (HOYA CORP), 30 July 1996 (1996-07-30) abstract	1,30
A	----	14,22, 38,43
X	EP 0 448 989 A (IBM) 2 October 1991 (1991-10-02) abstract; figures 1,3,6 column 10, line 30 - line 51 ----	1,30
X	US 5 535 034 A (TANIGUCHI SHOJI) 9 July 1996 (1996-07-09) abstract; figure 1 column 3, line 53 - column 4, line 63 claim 1 ----	1,30
A	PATENT ABSTRACTS OF JAPAN vol. 097, no. 001, 31 January 1997 (1997-01-31) -& JP 08 248277 A (FUJITSU LTD), 27 September 1996 (1996-09-27) abstract	1
A	EP 0 652 696 A (AT & T CORP) 10 May 1995 (1995-05-10) abstract; figures 1,2 claim 1 -----	1-47

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/08447

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 09171127	A	30-06-1997	NONE	
JP 01098299	A	17-04-1989	NONE	
JP 08194129	A	30-07-1996	NONE	
EP 0448989	A	02-10-1991	US 5005939 A CA 2036959 A,C DE 69114161 D DE 69114161 T JP 2828220 B JP 7030133 A	09-04-1991 29-06-1993 07-12-1995 30-05-1996 25-11-1998 31-01-1995
US 5535034	A	09-07-1996	JP 7162186 A	23-06-1995
JP 08248277	A	27-09-1996	US 5875047 A	23-02-1999
EP 0652696	A	10-05-1995	US 5416668 A DE 69408782 D DE 69408782 T JP 2854254 B JP 7183681 A	16-05-1995 09-04-1998 02-07-1998 03-02-1999 21-07-1995